Anatomy of flowering Plants

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★ Study of internal str. of plants → Anatomy

- Plants → cells → basic unit → org. into → tissue → org. into → organs
- Within angiosperm → monocot & dicot → anatomically different

different organs in plant shows difference in internal structure

★ Internal structures show adaptation to → Diverse Environment ★

~~Imp~~

THE TISSUES → Grp of cells having → common origin / usually performs → common function

Plant is made up of different kinds of tissues mainly on basis of whether cells being formed are capable of dividing or not

Meristematic | Permanent

MERISTEMATIC TISSUES

Growth in plants → Largely restricted to → Specialised region of active cell division → called meristems

Plants have diff. kinds of meristems

primary meristems → occur early in life of a plant & contribute to form. of plant body

Apical Meristems

Meristems which occur at tips of roots & shoots and produce primary tissues

RAM occupies → tip of root

SAM occupies → distant most region of stem axis

During the ① form. of leaves & ② Elongation of stems

Intercalary meristems

Meristems which occur in mature tissues

- Occur in → Grasses → regenerate parts removed by grazing herbivore.

Secondary/Lateral Meristem

Occur in mature region of → roots / shoots

particularly those which produce woody axis & appear later than primary meristem.

- These are cylindrical meristem.
- Responsible for producing → sec. tissue

Eg. Fascicular V. cambium, Interfascicular " ", Cork cambium

Some cells left behind form SAM

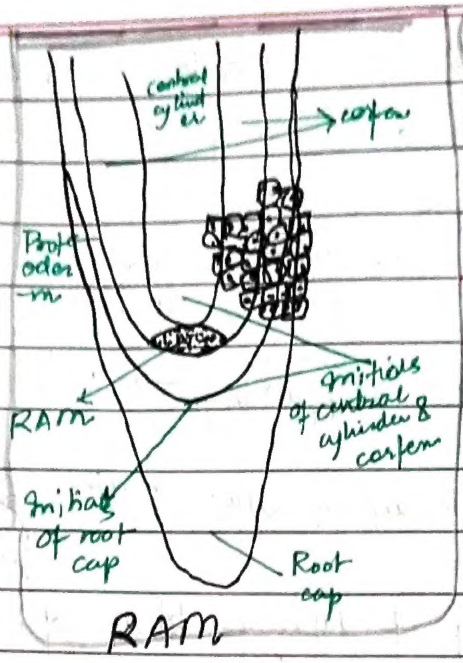
constitute

Axillary bud

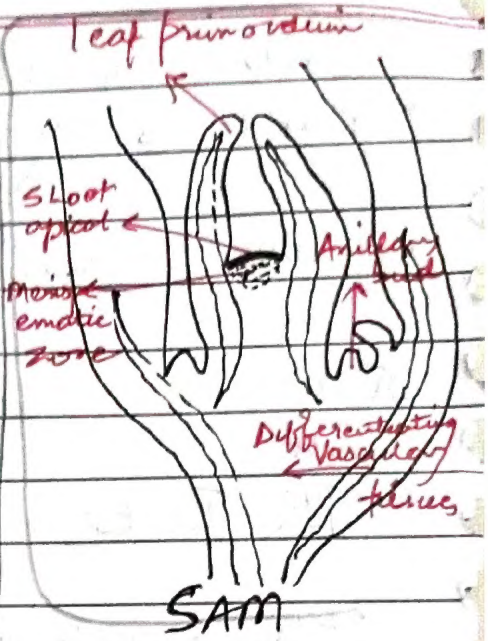
present in axils of leaves

capable of forming

branch flower.



RAM



SAM

* Following divisions of cells in both → primary, → secondary meristem

newly formed cells become → structurally, functionally → specialised

such cells → lose ability to divide

Permanent / mature cells

consist → permanent tissues

- During the form of primary plant body

Specific regions of apical meristem

produce

Dermal tissues

Ground tissues

Vascular tissues

PERMANENT TISSUES

Simple tissues
All cells similar in structure & function

Complex Tissues
having many diff. types of cells which do not dissolve together.

Parenchyma

- Forms major component within organs of plant.
- Cells of parenchyma
  - Isodiametric
  - May be
    - Polygonal
    - Elongated
  - On shape
    - Spherical
    - Oval
    - Round
- Cell walls → Thin → cellulosic
- Either
  - Closely packed
  - OR → have small intercellular spaces
- Functions → Secretion
  - Photosynthesis
  - Storage

Collenchyma

Occurs in → Layers below epidermis in most dicot plants.

Found as
- Homogeneous layer
- OR
- Patches

Cells → Much thickened at corners due to deposition of
- Cellulose
- Hemicellulose
- Pectin

Cells of this tissue may be
- Oval
- Spherical
- Polygonal

often contain chloroplast → these cells assimilate → when contains chloroplast

- Provide — mechanical support to the growing parts of plant eg
  - Young stem
  - Petiole of leaf

provides mechanical support to organs

Sclerenchyma

Consists of
- Long
- Narrow
- Thick lignified walls
- Few or numerous pits

- Usually dead → without protoplast
- On basis of origin, form, structure, development

Sclerenchyma may be either

Fibres
- Thick
- Elongated
- Pointed cells
- Generally in groups in various parts of plant

Sclereids
- spherical
- oval
- cylindrical
- highly thick ened dead cells → with narrow cavities lumen

- Found in
  - Fruit wall of nuts
  - Pulp of fruits like → guava, pear, sapota
  - Seed coat of legumes
  - Leaves of tea

Complex tissues

made up of more than one type of cells
work together as a unit
constitute → Xylem
→ Phloem.

XYLEM

conducting tissue for
water ← from soil → minerals

Provides – Mechanical strength to plant parts

Xylem (Gymnosp. lack this)

Tracheids	Vessels	Xylem fibres	Xylem Parenchyma
• Elongated • Tube like • Tapering ends • Thick, lignified walls • Dead without protoplasm • Inner layers of cell walls have thickening which vary in form.	• Long • Cylindrical • Tube like • made up of many cells → Vessel member each has • lignified walls • large central cavity Dead • Vessel cells devoid of protoplasm • Vessel members interconnected through Perforation in their common walls.	• Highly thickened walls • Obliterated central lumens • Either be SEPTATE / ASEPTATE Dead	• Living • Thin walled • Cell walls of cellulose • Store food in form of starch / fat / other substances like tannins The radial conduction of water take place by Ray parenchyma cells

*Presence of vessel — charact. of → Angiosperm

• Tracheids / Vessels → main water transporting element in flowering plants.

Primary Xylem — two types

Protoxylem	Metaxylem
• 1st formed primary xylem	• Later formed primary xylem

Two types of arrangement

Endarch	Exarch
Proto – pith Meta – peripheral Eg. Stems	opposite Eg. Roots

PHLOEM

transports food material → form → leaves → to other parts of plant

→ in gymnosperm.

Phloem in angiosperm composed of

Sieve tube Elements	Companion cells	Phloem Parenchyma	Phloem fibres
• Long • Tube like arranged longitudinally • Associated with companion cells • Their end walls perforated in Sieve like manner to form Sieve plates • A mature Sieve element has Lack nucleus, Peripheral cytoplasm, Large vacuole	(Specialised parenchymatous cells) • closely associated with sieve tube elements • connected to sieve tube elements by pit fields present b/w their common longitudinal walls. • Functions help in maintaining pressure gradient in sieve tube	made of • Elongated tapering • Cylindrical cells • Dense cytoplasm • Nucleus (cellulose) Cell Wall has pits through which plasmodesmatal connection exists b/w the cells. • Stores → food → resin → latex → mucilage * Phloem parenchyma absent in monocots	Bast fibres made up of Sclerenchymatous cells • Absent in primary phloem • Found in sec. phloem • Elongated • Unbranched • Pointed • needle like apices Cell wall → thick At maturity these fibres lose protoplasm → become dead. • Phloem fibres of Flax, jute, hemp used commercially

Functions of sieve tubes are controlled by nucleus of companion cells.

Protophloem	Metaphloem
First formed primary phloem → consists of narrow sieve tubes	Later formed primary phloem → consists of bigger sieve tubes

parenchy. collenchyma Schlerenchyma.

THE TISSUE SYSTEM. → Based on types of cells present

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Based on location in the plant body

* Their → structure → function would also be dependant on location.

Epidermal Tissue system	Ground/Fundamental tissue system	Vascular/Conducting tissue system

* On Basis of → structure, Location → 3 types of tissue system.

Epidermal Tissue System.

→ Forms : outermost covering of whole plant body

→ Composes → Stomata, Epidermal cells
→ Epidermal appendages → trichomes, hairs

☆ EPIDERMIS : Outermost layer of primary plant body

made up of → Elongated, compactly arranged → cells → which form continuous layer.

usually → single-layered.

☆ Epidermal Cells → • Parenchymatous
• Small amt of cytoplasm lining cell wall
• Large vacuole.

☆ Outside of Epidermis covered by → Cuticle
• Waxy
• Thick layer.

* Cuticle absent in roots.

☆ Epidermis of leaves has → STOMATA
regulate the process of → Transpiration, Gaseous exchange

* Stomata composed of → 2 bean shaped cells known as → Gaurd cells.
↓ enclosed
Stomatal pore.

* In Grasses Gaurd cells → Dumbell shaped.

Outer wall of stomata → away from stomatal pore → thin

Inner wall of stomata → towards stomatal pore → highly thickened

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★ Gaurd cells → possess chloroplast
└ regulate → • opening • closing → of the stomata.

★ Few epidermal cells → in vicinity of gaurd cells → become specialised in shape and size → known as Subsidiary cells

Stomatal Aperture + Gaurd cell + Surrounding subsidiary cell.
↓
Stomatal apparatus.

Cells of Epidermis bear → number of hairs

Root hairs

⊙ Unicellular elongations of epidermal cells

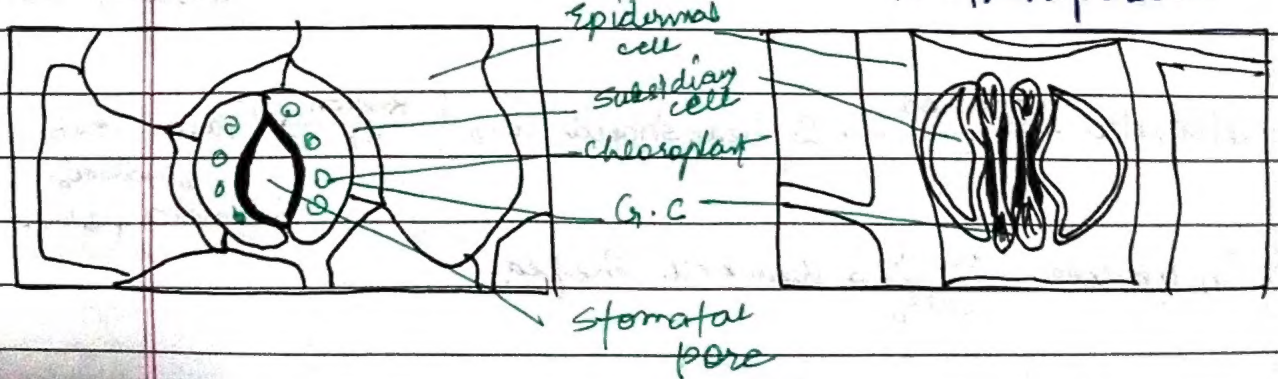
⊙ Help absorb → water, minerals → from soil

Trichomes → secretory

⊙ On stems, these epidermal hairs present.

In shoot system → trichome → Multicellular → maybe Branched OR Unbranched and Soft OR Stiff

⊙ Prevents water loss due to transpiration



GROUND TISSUE SYSTEM. → main bulk of plant

divided into

All tissue except epidermis, Vascular bundles

consists of lot of simple tissues

Cortex | Pericycle | Pith

Parenchyma | Collenchyma | Sclerenchyma

Parenchyma cells present in

- Cortex
- Pericycle
- Pith
- Medullary rays
- In primary → stem, root

In Leaves — Ground tissue

consists of

- thin walled
- Chloroplast containing cells

called mesophyll.

VASCULAR TISSUE SYSTEM

consists of Complex tissue

Xylem | Phloem

together constitute → Vascular Bundle.

DICOT STEM →

Xylem | cambium | Phloem

① Sec. Xylem

② Sec. Phloem

Hence, such vascular bundles possess the ability to form

OPEN VASCULAR BUNDLE ← hence called

MONOCOTYLEDONS → V.B ✗ no cambium

↓ do not form Secondary tissues

CLOSED V.B ← Hence called

★ On basis of → presence of cambium
→ location of → Xylem, Phloem

V.B are of different types

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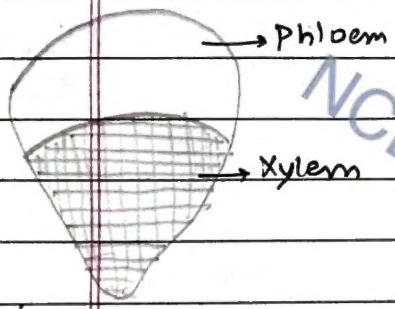
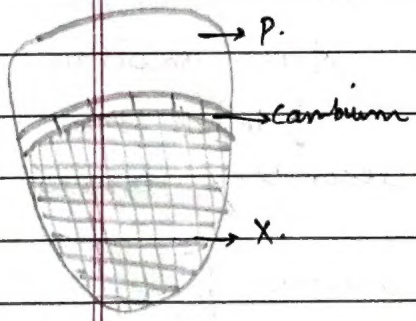
CONJOINT

- Xylem Phloem
  - ↓
  - Jointly situated along the same radius of V.B
- Eg in → Stems, Leaves

* Usually have
↓
phloem on outer side



* Conjoint closed



* Conjoint open.

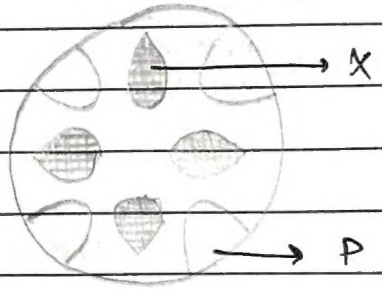
RADIAL

↓

Xylem Phloem
↓
within V.B

arranged in alternate manner along the
↓
different radii

Eg in → Roots



DICOT ROOT

Transverse section of SUNFLOWER ROOT

Outermost layer : Epiblema

Unicellular Root hairs ← many cells of epiblem protude in form of

CORTEX consists of several layers of

- thin walled
- Parenchymat. cells
- ~~Intercellular spaces~~

its innermost layer → ENDODERMIS

comprises

- single layer of Barrel shaped cells
- without any intercellular spaces

Endodermal cells

Tangential wall — have deposition of Suberin in form of CASPARIAN STRIPS — Radial wall

Suberin: water impermeable, wavy

Next to endodermis → PERICYCLE

consists of

- Few layers of
  - ② thick walled
  - ① Parenchymatous cells

- Initiation of
  - ① Vascular cambium
  - ② lateral roots

during secondary growth takes place in pericycle

MONOCOT ROOT

Anatomy of monocot root similar to Dicot Root. (in many respects)

Has →
- Epidermis
- Cortex
- Endodermis
- Pericycle
- Vascular Bundles
- Pith

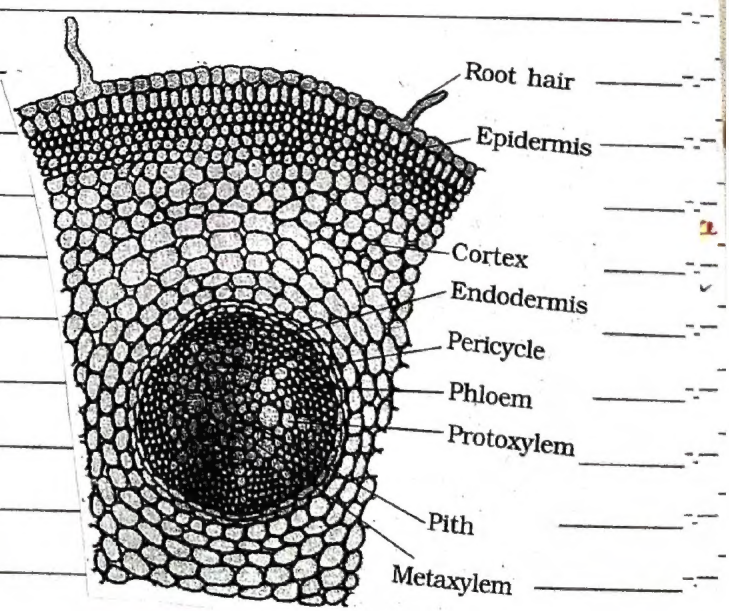
Xylem bundles → usually more than 6.

POLYARCH

PITH → Large

Well developed

★ Monocot Root → ✗ Sec. growth



Transverse sect.

PITH → • Small
• Inconspicious

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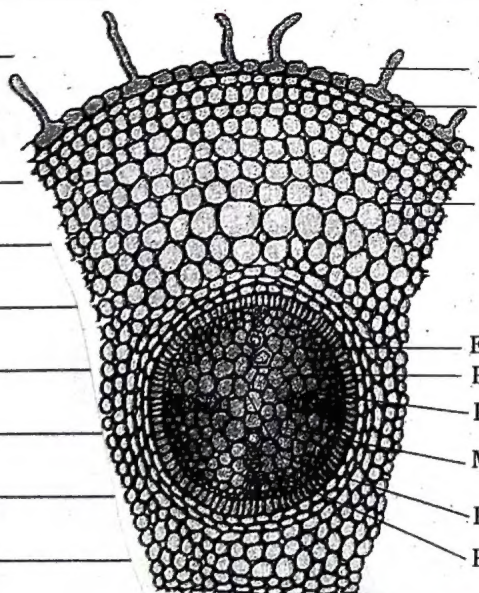
Xylem -- PARENCHYM. CELLS -- Phloem
in b/w
↓called
Conjuctive tissue

usually no. present
↓
2 – 4

Later, Cambium Ring develops b/w xylem & phloem

ENDODERMIS
INNERSIDE
All tissues
↓
constitute stele
↓
- Pericycle
- Vascular Bundles
- Pith



Transverse sec.

DICOT STEM

TRANSVERSE SECTION of Young Dicot stem.

shows

- **Epidermis**
  - Outermost ⊙ Protective layer
  - Covered with → thin layer of cuticle.
  - may bear
    - Trichomes
    - few stomata.
  - Cells arranged in → multiple layers b/w epidermis & pericycle
  - constitute → **Cortex**
    - consists of 3 sub-zones

Outer	Middle	Inner
Hypodermis	**Cortical layers**	**Endodermis**
Few layers of collenchymatous cells just below epidermis	• Below the hypodermis • Consists of → • Round • Thin walled • Parenchymatous cells • Has conspicuous intercellular spaces.	• Cells rich in starch grains hence this layer referred Starch sheath On INNER SIDE OF ENDODERMIS present **Pericycle** • Above phloem • Form of semi-lunar patches of sclerenchyma
provide → Mechanical strength to young stem.		

- **IN B/W VASCULAR BUNDLES** there are
  - Few layers of
  - Radially placed
  - → PARENCHYMATOUS CELLS constitute → medullary rays

MONOCOT STEM

Hypodermis — Sclerenchymatous

Large no. of Scattered **Vascular Bundles**

each surrounded by Sclerenchymatous bundle sheath

- Large
- Conspicious → Ground tissue
- Parenchymatous

Vascular Bundle

-) Conjoint
-) Closed

Peripheral Vascular Bundle

↓

Smaller generally than centrally located ones

★ Phloem parenchyma → absent

★ Water containing cavities present within Vascular Bundle.

LARGE NO OF → VASCULAR BUNDLES

A ring ← arranged in

This ring arrangement → Characteristic of dicot stem.

EACH Vascular Bundle

↓

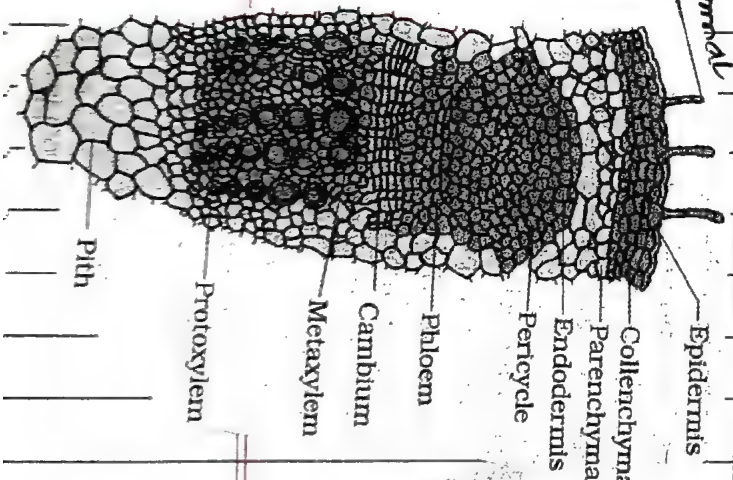
1) Conjoint
2) Open
3) Endarch protoxylem

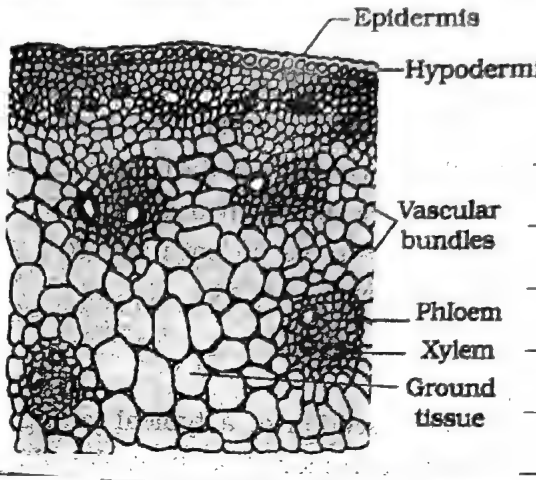
PITH → Large no. of
- Rounded
- Parenchymatous cells
- Large intercellular spaces cells

constitute → Central portion of stem

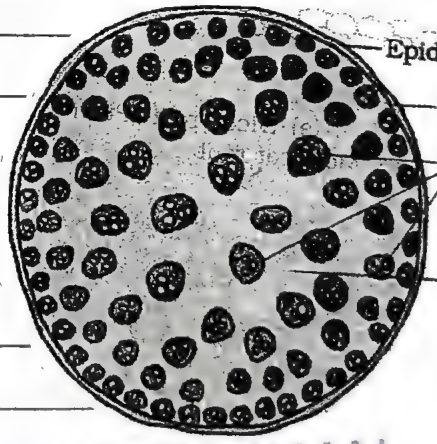
occupy

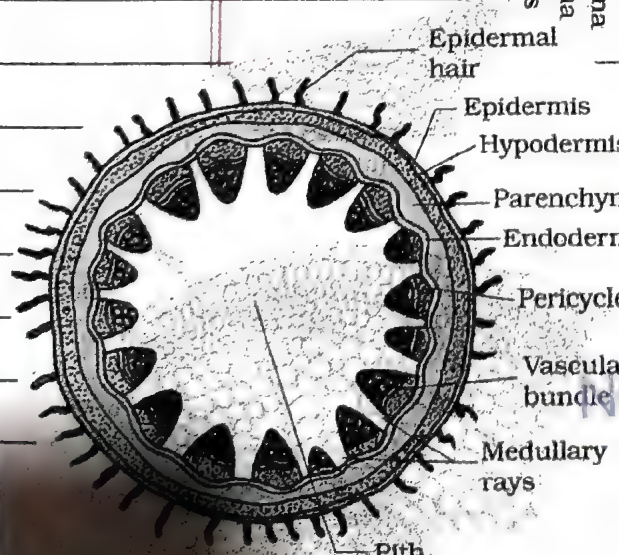
Transverse sect.





Transverse sect.





DICOT LEAF
(Dorsiventral leaf)

- Vertical Section through the Lamina shows 3 main parts

Epidermis (has conspicuous cuticle)

- Adaxial surface → Upper
  - Less stomata (may even lack stomata)
- Abaxial surface → Lower
  - More stomata

Tissue b/w upper & lower epidermis

- Posses chlorophyll.
- Carry out photosynthesis.
- Made of Parenchyma
- 2 types of cells

Palisade Parenchyma	Spongy parenchyma
• Adaxially placed	• Oval
• Elongated cells	• Round
• Arranged, vertically & Parrallel to each other.	• Loosely arranged
	• Situated → below palside cells ↓ extend to lower epidermis
• Compact	• Has numerous large space & air cavities

VASCULAR SYSTEM →

- Has vascular bundles seen in
  - Veins
  - midrib

★ Size of vascular bundles ↓ depend on size of veins

MONOCOT LEAF
(Isobilateral leaf)

Anatomy of monocot leaf & dicot leaf similar in many ways

Characteristic differences →

★ Stomata – present on both surface

★ Mesophyll – not differentiated into palisade & spongy

In GRASS,

Certain adaxial Epidermal cells ↓ along the veins ↓ modify themselves into

large colourless cells & empty cells

↓

Bulliform cells

↓ these when absorb Water ↓ becomes turgid. ↓ then

Leaf surface – exposed.

↓ when flaccid due to water stress

leaves curl inwards ↓ tend to minimize water loss

Veins —(vary in)→ thickness —(in)→ Reticulate venation

Parallel venation —(in)→ monocot leaves

↓ reflect

Vascular Bundles —(surrounded by)→ BSC

↓

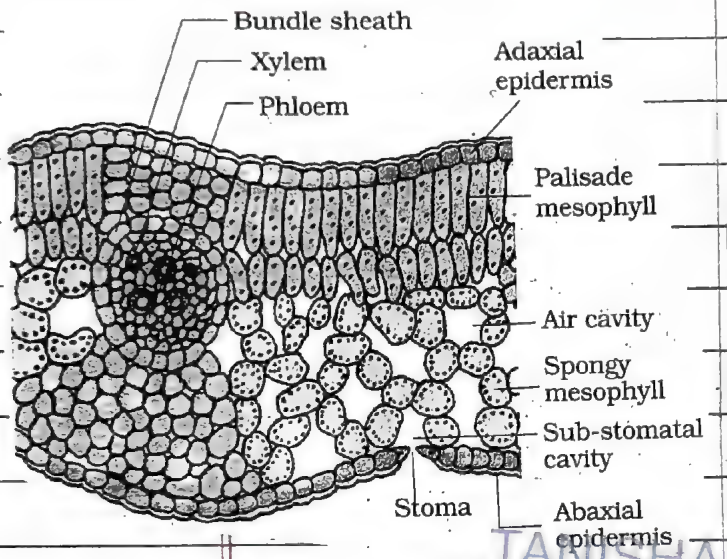
Bundle sheath cells

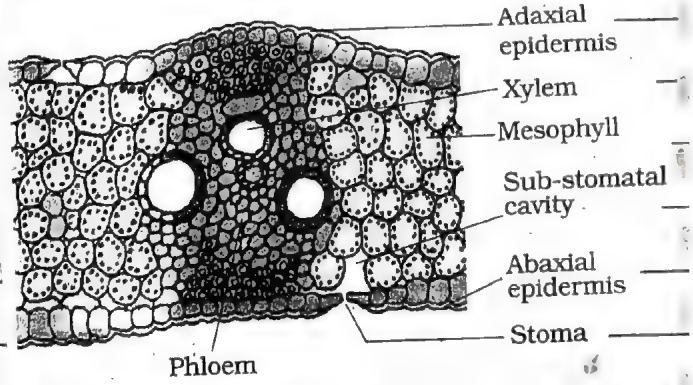
Similar size of vascular bundles

(except in main veins)

↓

as seen in vertical sections of leaves.





SECONDARY GROWTH

Primary growth ↑ in length of → Roots, Stems — occurs with the help of → Apical Meristem & lateral meristems

Most dicotyledons — exhibit → ↑ in girth — called Secondary growth tissue involved → Cork cambium, Vascular cambium

VASCULAR CAMBIUM

- meristematic layer
- responsible for cutting off vascular tissues → xylem, Phloem.
- In young stems → present in patches as single layer b/w xylem & phloem.
- Later → forms complete ring

Formation of Cambial Ring

In dicot stems → "Cells of cambium" present b/w xylem & phloem (primary) → called → Intrafascicular Cambium

"Cells of medullary rays" adjoining these intrafascicular cambium become meristematic → form → Interfascicular Cambium

Thus → A continuous ring formed.

Activity Of Cambial Ring

becomes active & begins to cut off cells towards

Inner side

- Cells cut off towards pith → mature into Secondary xylem
- Cambium more active
- Amt produced is more
- Soon forms a compact mass

Outer side

- Cells cut off towards periphery → mature into Secondary phloem
- Cambium less active
- Amt produced is less

★ Secondary phloem ★ prim p.-ary

↓

Gets crushed due to continued form. of & accumulation of secondary xylem

⊙ Primary Xylem ⟶ More of less ① Remain Intact. OR ② Around the centre.

✱ At some places ⟶ Cambium forms ⟶ narrow bands of Parenchyma

Secondary Medullary Rays ← forming [in radial direction ↔ Sec. xylem / Sec. phloem ← which passes through]

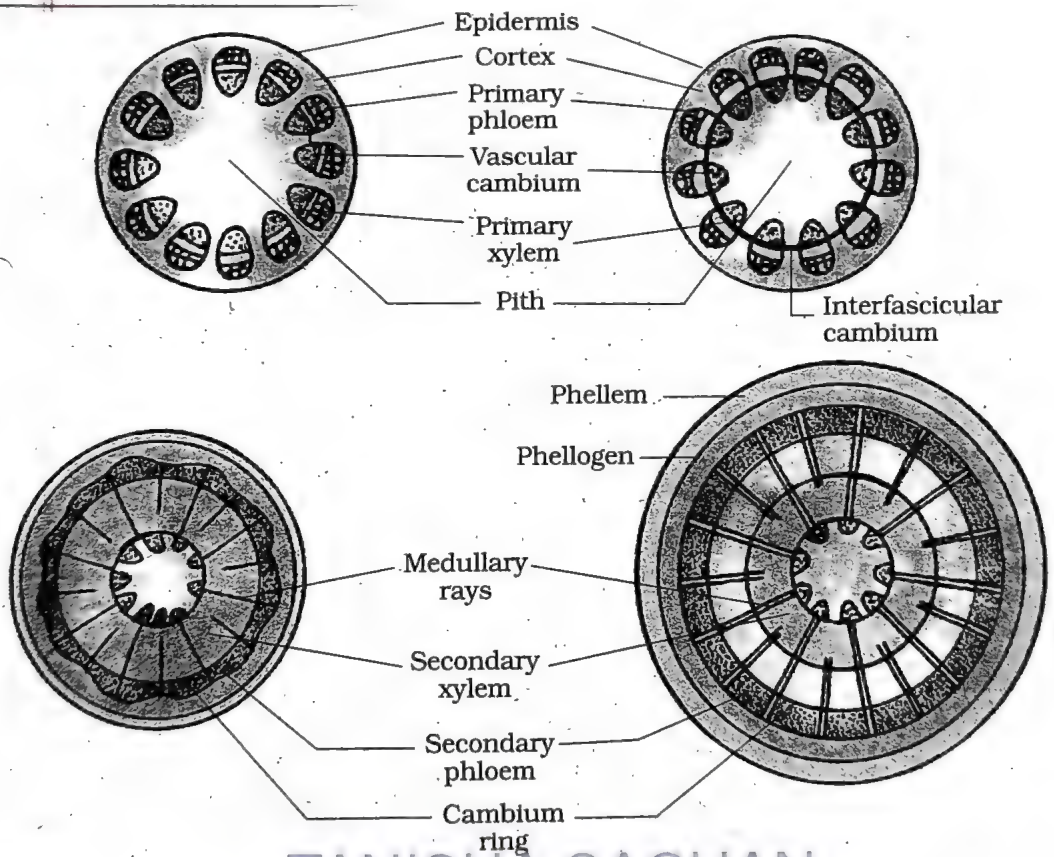


Figure 6.9 Secondary growth in a dicot stem (diagrammatic) – stages in transverse views

Wood —is actually→ Secondary Xylem

Different types of woods — on basis of → their composition / time of production

Spring Wood / Early Wood

- In spring season
- Cambium very active
- produces
- Large no. of Xylary elements with wider cavities
- vessels with
- Lighter in colour
- Low density

Autumn Wood / Late wood

- In winter (x not autumn)
- Cambium less active
- produces
- Fewer no. of Xylary elements with narrow vessels
- Darker in colour
- Higher density

Two kinds of woods that appear as alternate concentric rings

constitute

Annual Rings — seen in cut stem (this gives) → estimate the age of trees

Activity Of Cambium → under the control of physiological & environmental factors.

1.
2.

In temperate region — climatic conditions → Not uniform through the year.

Hence, autumn & spring wood is formed.

Heartwood (duramen)

In old trees

↓

Greater part of Sec. Xylem

↓

Dark brown in colour due to deposition of organic compounds like:

1. tannins
2. resins
3. oils
4. gums
5. aromatic substances
6. essential oils

↓

In central & innermost layers of stem.

Sapwood (albumum)

Peripheral Region of Sec. Xylem

↓

Lighter in colour

↓

Involved in conduction of water & minerals from root to leaf.

- These substance make it
  - hard
  - durable
  - Resistant
    1. to attacks of micro-organisms
    2. insects

This region have dead elements with highly lignified walls.

- Does not conduct water but gives mechanical strength to stem.

CORK CAMBIUM

Stems → continue to → ↑ in girth → due to activity of → Vascular Cambium

Vascular Cambium → ① Outer cortical ② Epidermis layer → get broken → need to be replaced to provide new protective cell layers

hence sooner or later → Another meristematic tissue → Cork Cambium formed. OR PHELLOGEN

PHELLOGEN → in • Cortex region

Couple of layers thick → made of
- narrow
- thin-walled
- nearly rectangular cells

cuts off cells on both sides

Outer cells → differentiate into → Cork OR PHELLEM → impervious due to → Suberin deposition in the cell wall.

PHELLOGEN + PHELLEM + PHELLODERM → PERIDERM.

Inner cells → differentiate into → Secondary cortex OR PHELLODERM → Cells: Parenchymatous

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★ Due to activity of the cork cambium → pressure builds up on remaining layers peripheral to phellogen. → ultimately → These layers die & slough off.

★ Bark → is a non-technical term

→ Refers to → ★ All tissues exterior to Vascular Cambium therefore including Sec. Phloem

includes → Periderm, Sec. Phloem

Early / Soft bark — Formed early in season

Late / Hard Bark — Formed late/end in season.

★ At certain regions → Phellogen cuts off loosely arranged parenchymatous cells on outer side instead of cork cells. These parenchym. cells → Soon rupture the epidermis → forming → Lens shaped openings → Lenticels.

Lenticels → permit → gas exchange of gases b/w the outer atmosphere & internal tissues of stem

→ Occur mostly in woody trees.

Sec. Growth in Roots

Vascular Cambium → Completely secondary in origin

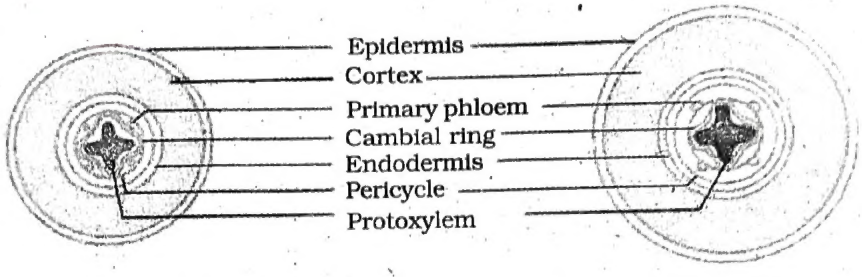
originated from

Complete & Continuous → Wavy ring

forming ← ① Fusiform located just below the phloem bundles ② a portion of pericycle tissue ③ above protoxylems

later which becomes → Circular

* Further events are similar to that of dicot stem.



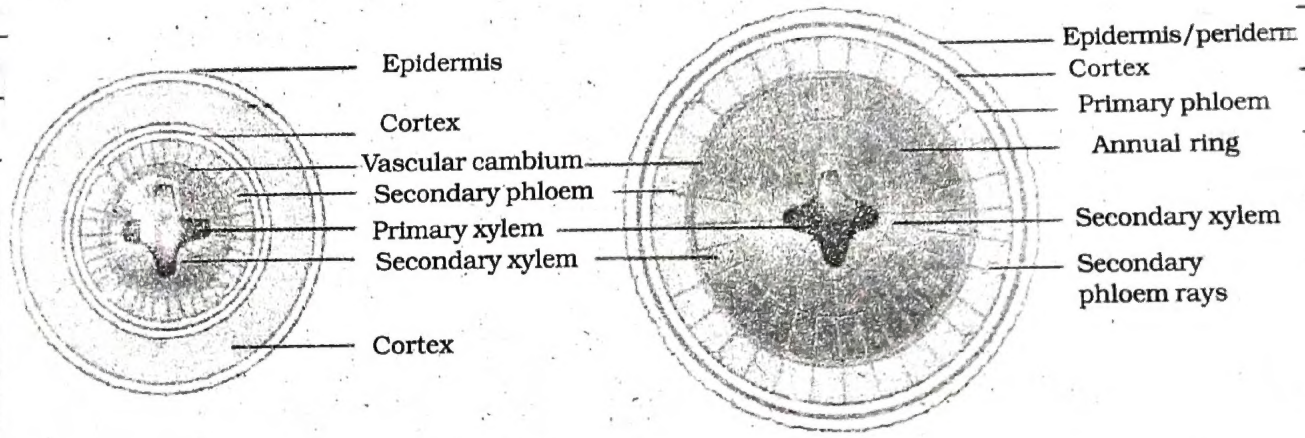


Figure 6.11 Different stages of the secondary growth in a typical dicot root

Sec. growth occurs in → stems, roots → of gymnosperm

↓ X

monocot